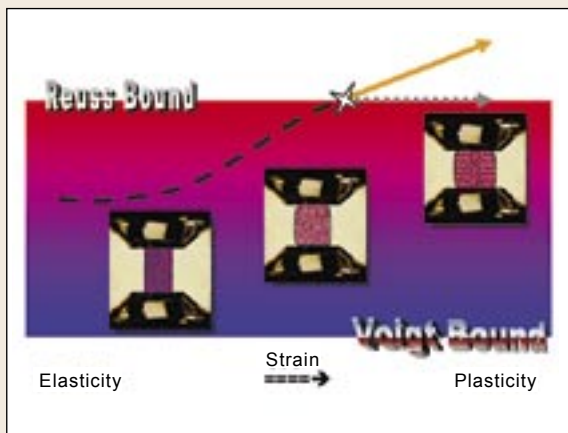


## BREAKING THE BOUNDS OF PLASTICITY

In order to understand the planet we live on, it's crucial to understand the properties of the liquid- and plastic-like minerals flowing beneath the Earth's crust. The study of the deformation and flow of these minerals, along with many other natural and manmade materials, is known as rheology. Many of Earth's surface features, such as mountain belts, subduction zones, hot spots and seismic zones, are significantly affected by mantle rheology. To study these minerals, scientists mimic mantle conditions with high-pressure, laboratory-based experiments and modeling theories. But at the NSLS, a team from Stony Brook University found that a commonly used model in previous studies might be inaccurate.

The conventional method of modeling stress and strain propagation in materials uses two extreme bounds, called Reuss and Voigt bounds. The Reuss bound describes a condition where all the grains in a sample experience identical stress when forces are applied to the material. The Voigt



The research group experimentally determined that the stress propagation parameter went beyond the classic Reuss (isostress) bound at larger strains.

bound describes a condition where all the grains experience the same strain when the sample is deformed under stress. Intermediate conditions are described by combining the bounds to achieve a weight parameter between 0 and 1, with 0 representing the Voigt bound and 1 representing the Reuss bound.

Using a new technology at beamline X17B2, the Stony Brook team found that this parameter can actually exceed 1, the Reuss bound. This event occurs when a sample is pushed beyond its normal elastic state. Typically, when a force is applied and removed from a sample, the material will bounce back to its initial form. But if the force is greatly

increased, the material will undergo an unrecoverable change, a characteristic known as plastic deformation. It's in this situation that the classic Reuss and Voigt model fails. "For the first time, we can quantitatively recognize that this parameter under plastic deformation can go beyond the boundary," said researcher Jihua Chen. "That means that this classic elastic model can no longer be applied in this situation."

The finding wouldn't have been possible without the development of a new type of x-ray diffraction experiment, Chen said. Traditionally, scientists have used one detector at a fixed angle to study materials under high pressure. But with the help of NSLS scientists Zhong Zhong and Chi-Chang Kao, the team developed a simultaneous multi-diffraction detection system that can detect x-ray diffraction along and normal to the applied principal stress.

"These techniques have offered means to reveal the information of material properties that was not obtainable before and have also enabled many reformations of traditional experiments," Chen said. "This technical development will really enable us to study the rheological properties of Earth's materials at a much higher pressure than before. And now we can explore the mantle at even deeper levels."

Other scientists involved in this study, which was published in the June 28, 2006 edition of the *Journal of Physics: Condensed Matter*, include Li Li, Tony Yu, Hongbo Long, Donald Weidner, Liping Wang, and Michael Vaughan, all from Stony Brook University. Funding was provided by the Consortium for Materials Properties Research in Earth Sciences and the National Science Foundation.

For more information, see: J. Chen, L. Li, T. Yu, H. Long, D. Weidner, L. Wang, and M. Vaughan, "Do Reuss and Voigt Bounds Really Bound in High-Pressure Rheology Experiments?" *J. Phys. Condens. Mat.*, **18**, S1049-1059 (2006).

— Kendra Snyder